

REVISION OF SECTIONS 105, 202, 401, 406 and 601
HOT MIX ASPHALT PAVEMENT ROADWAY SMOOTHNESS
(HIGH SPEED PROFILER)

Sections 105, 202, 401, 406, and 601 of the Standard Specifications are hereby revised for this project as follows:

Delete subsection 105.07 and replace with the following:

105.07 Conformity to Roadway Smoothness Criteria. Roadway smoothness testing and corrective work shall be performed as described below.

(a) *Smoothness Quality Control Testing.*

1. The Contractor shall perform Smoothness Quality Control (SQC) testing. The test results shall be submitted to the Engineer within 48 hours of completion. SQC test results shall show the Half Car Roughness Index (HRI) or Percent Improvement (%) for each 0.10 mile or 0.05 mile section respectively. When the Contract specifies HRI, the test results shall show the results for localized roughness.

All traffic control costs associated with SQC testing will be paid for in accordance with Section 630.

When the Contract specifies HRI Category I, SQC results shall be in the form of HRI, SQC shall be performed on the first 2,000 tons for the final layer.

When the Contract specifies HRI Category II, SQC results shall be in the form of HRI. SQC shall be performed on the first 2,000 tons for both the final layer and the next lower pavement layer and at the completion of the next lower pavement layer.

When the Contract specifies HRI Percent Improvement, SQC results shall be in the form of HRI and HRI Percent Improvement. SQC shall be performed on the first 2,000 tons for the final layer.

SQC testing shall be performed using the Contractor's inertial profiler, pursuant to the methods described in subsection 105.07(b) and in accordance with the manufacturer's recommendations. The Contractor's Profiler shall be certified according to CP 78. A list of certified profilers is located at <http://www.dot.state.co.us/DesignSupport/>

Production shall be suspended if SQC testing indicates that corrective work is required in accordance with subsection 105.07 (c). Production will remain suspended until the problem is identified and corrected. Each time production is suspended, corrective actions shall be proposed in writing by the Contractor.

When production resumes, the Contractor shall profile the first 2,000 tons of HMA. The conditions above for suspension of work will apply.

2. The finished transverse and longitudinal surface elevation of the pavement shall be measured using a 10 foot straightedge. Areas to be measured will be directed by the Engineer. The Contractor shall furnish an approved 10 foot straightedge, depth gauge and operator to aid the Engineer in testing the pavement surface. Areas showing high spots of more than 3/16 inch in 10 feet shall be marked and diamond ground until the high spot does not exceed 3/16 inch in 10 feet.

(b) *Smoothness Acceptance Testing.* The Contractor shall perform Smoothness Acceptance Testing (SA) which will be used for acceptance and calculation of incentive and disincentive payments.

All traffic control costs associated with SA testing will be paid for in accordance with Section 630.

1. Longitudinal Pavement Surface Smoothness Acceptance. Pavement surfaces shall be tested and accepted for longitudinal smoothness as described herein.
 - A. Testing Procedure (General). The longitudinal surface smoothness of the final pavement surface shall be tested and evaluated by the Contractor in accordance with CP 74 and using the

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Contractor's high-speed profiler (HSP). The Contractor's Profiler shall be certified according to CP 78. A list of certified profilers is located at <http://www.dot.state.co.us/DesignSupport/>

The HSP instrumentation shall be verified in accordance with CP 74 prior to measurements. The Contractor shall lay out a distance calibration site. The distance calibration site shall be 1056 feet long and shall be on a relatively flat, straight section of pavement as approved by the Engineer. The site shall have a speed limit equal to the Project's highest speed limit that allows for the HSP to operate uninterrupted. The limits of the site shall be clearly marked and the distance shall be measured to an accuracy of +/- 3 inches. The Contractor shall provide in writing the site location to the Engineer. The cost of the distance calibration site will not be measured and paid for separately, but shall be included in the work.

The entire length of each through lane, climbing lane and passing lane including bridge approaches, bridge decks and intersections from the beginning to the end of the project shall be profiled. Shoulders, ramps, tapers, turn slots, acceleration lanes, deceleration lanes, and medians shall not be profiled and will not be subject to incentive/disincentive adjustments. The profile of the entire length of a lane shall be taken at one time. However, the Contractor may break a project into sections to accommodate varying conditions or Project phasing if approved by the Engineer.

A sufficient distance shall be deleted from the profile to allow the profiler to obtain the testing speed plus a 300 foot distance to stop and start when required. Incentive/disincentive payments will not be made for this area. The final surface of these areas shall be tested in accordance with subsection 105.07(a) 2.

Shoulders, ramps, tapers, turn slots, acceleration lanes, deceleration lanes, and medians constructed as part of this project shall be measured in accordance with subsection 105.07(a) 2.

When the Contract Specifies HRI, the following applies:

- (1) The profile shall include transverse joints when pavement is placed by the project on both sides of the joint. When pavement is placed on only one side of the joint, the area 25 feet from the joint shall be deleted from the profile before the HRI is determined. Incentive/disincentive payments will not be made for this area. Pavement within the area 25 feet on the newly constructed side of the joint shall be tested in accordance with subsection 105.07(a) 2.
- (2) The profile of the area 25 feet each side of every railroad crossing, cattle guard, bus pad, manhole, valve box, gutter pan and intersection (where there is a planned breakpoint in the profile grade line in the direction of testing) shall be deleted from the profile before the HRI is determined. Incentive/disincentive payments will not be made for these areas. Areas deleted from the profile shall be tested in accordance with subsection 105.07(a) 2.
- (3) When both new pavement and a new bridge or new bridge pavement are being constructed in a project, the profile of the area 25 feet each side of every bridge expansion device (joint) shall be deleted from the profile before the HRI is determined. Incentive/disincentive payments will not be made for this area. Areas deleted from the profile shall be tested in accordance with subsection 105.07(a) 2. Diamond grinding will not be measured and paid for separately, but shall be included in the work. For all other projects, the profile of the area 25 feet each side of every bridge expansion device (joint) shall be deleted from the profile before the HRI is determined. Incentive/disincentive payments will not be made for this area. If the Engineer determines that corrective work is required in this area, payment will be made in accordance with subsection 109.04.
- (4) The Contractor shall notify the Engineer in writing at least five working days in advance of his intention to perform SA testing. The Contractor shall profile the Project within 14 days after the completion of paving operations. The Engineer will witness the SA profiling and take immediate possession of the SA data.

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- (5) The Contractor shall not perform any corrective work that will effect the pavement smoothness for ten working days after completion of the SA testing or as approved by the Engineer. This time is to allow for the Department to analyze the data and perform smoothness verification testing.

When the Contract specifies HRI Percent Improvement, the Contractor shall comply with the following:

- (1) The Contractor shall notify the Engineer in writing of his intention to perform initial SA testing. This notification shall be at least five working days in advance of any work that will affect the smoothness of the lanes. This includes but is not limited to the following work; manhole adjustment, valve box adjustments, curb and gutter repair, milling, planing or patching.
 - (2) The Contractor shall perform the initial SA testing prior to any work that will affect the smoothness of the lanes. The Engineer will witness the SA profiling and take immediate possession of the SA data.
 - (3) The Contractor shall not perform any work that will effect the initial smoothness of the lanes for ten working days after completion of the initial SA testing or as approved by the Engineer. This time is to allow for the Department to analyze the data and perform smoothness verification testing.
 - (4) When the Contractor performs work on the existing pavement prior to the initial SA testing, the affected sections will not be subject to incentive payments, but will be subject to disincentive payments and corrective work.
 - (5) The Contractor shall notify the Engineer in writing at least five working days in advance of his intention to perform final SA testing. The Contractor shall profile the Project within 14 days after the completion of paving operations. Manholes and valve boxes shall be raised prior to final SA testing. The Engineer will witness the SA profiling and take immediate possession of the SA data.
 - (6) The Contractor shall not perform any corrective work that will effect the final pavement smoothness for ten working days after completion of the final SA testing or as approved by the Engineer. This time is to allow for the Department to analyze the data and perform smoothness verification testing.
 - (7) The profile shall include an additional 25 feet of pavement outside the project paving limits.
- B. Smoothness Testing Procedures. The Contractor shall mark the project limits, climbing lane limits and passing lane limits. When the Contract specifies HRI the Contractor shall mark 25 feet from each bridge approach slab, railroad crossing, cattle guard, bus pad, manhole, valve box, gutter pan and intersection (where there is a planned breakpoint in the profile grade line in the direction of testing). When the Contract specifies HRI Percent Improvement, the markings shall be located in a location that will not be disturbed, so that the section start and stop locations shall be identical for the initial and final pavement surface. The Engineer will verify that the Contractor's marks are located properly. The Contractor shall use traffic cones with reflective tape or reflective tape on the pavement at the beginning and end of each lane for triggering the start and stop locations on the profiler and at any other location, where portions of the profile are being deleted. These locations shall be marked with temporary paint so that the Department's profiler uses the same locations for smoothness verification testing.

The Contractor shall clear the lanes to be tested of all debris before profiling.

The Contractor shall submit a Method for Handling Traffic (MHT) to the Engineer for approval at least five days in advance of SA testing. The MHT shall detail the methods for traffic control that

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shall allow for continuous non-stop profiling of each lane to be profiled at a minimum speed of 15 mph. The Contractor shall provide the traffic control in accordance with the approved MHT.

Each lane shall be profiled three times at a constant speed (+/- 5 mph) with a minimum speed of 15 mph and a maximum speed of 70 mph. The profile shall be taken in the intended direction of travel. The left and right wheel paths shall be profiled simultaneously. The collected profiles shall be turned over immediately to the Engineer and will be analyzed using CP 74.

- (1) When the Contract specifies HRI, the Department will determine a HRI for each 0.1 mile section or fraction thereof of completed pavement. The HRI consists of the average of the left and right wheel path's profile passed through the International Roughness Index (IRI) filter.

The Contractor's SA test results will be available within **ten** working days of the completion of SA testing. The Engineer will give the Contractor a report that will include profile data, the lane profiled, IRI for the left and right wheel paths, the HRI in 0.10 mile increments and a summary of areas requiring corrective work. The Engineer may determine that it is necessary for the Contractor to re-profile a lane

Areas requiring corrective work will be determined according to subsection 105.07(c) 1. The third run of each lane will be used for the determination of Localized Roughness.

Sections less than 0.01 miles in length shall not be subject to corrective work as specified by Table 105-6. Sections less than 0.01 miles in length shall be included in the Localized Roughness determination.

- (2) When the Contract specifies HRI Percent Improvement, the Department will determine an HRI for each 0.05 mile section or fraction thereof of pavement. The HRI consists of the average of the left and right wheel path's profile passed through the IRI filter.

The Contractor's SA test results will be available within **ten** working days of the completion of SA testing. The Engineer will give the Contractor a report that will include profile data, the lane profiled, IRI for the left and right wheel paths, the HRI in 0.05 mile increments, percent improvement in 0.05 mile increments and areas requiring corrective work. The Engineer may determine that it is necessary for the Contractor to re-profile a lane.

Areas requiring corrective work will be determined in accordance with subsection 105.07(c) 2.

- C. When the Contract specifies HRI, incentive/disincentive payments for pavement smoothness will be made on a square yard basis in accordance with the following:

Incentive and Disincentive payments will be based on the HRI for each 0.1 mile section or fraction thereof.

Incentive/Disincentive payments for Pavement Smoothness will be made in accordance with Table 105-6. Sections less than 0.01 miles in length will not be subject to disincentive payments.

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**Table 105-6
HMA PAVEMENT SMOOTHNESS (INCHES/MILE)
HALF-CAR ROUGHNESS INDEX**

Pavement Smoothness Category ¹	Incentive Payment (\$/sqyd)	No Incentive or Disincentive	Disincentive Payment (\$/sqyd)	Corrective Work Required
I	When HRI < 40.0 I = \$0.64	When HRI > 63.0 and < 72.0 I = \$0.00	When HRI ≥ 72.0 and ≤ 90.0 I = 2.560 - 0.03556 x HRI	When HRI > 90.0
	When HRI ≥ 40.0 and ≤ 63.0 I = 1.753 - 0.02783 x HRI		When HRI > 90.0 I = -\$0.64	
II	When HRI < 35.0 I = \$0.64	When HRI > 58.0 and < 67.0 I = \$0.00	When HRI ≥ 67.0 and ≤ 85.0 I = 2.382 - 0.03556 x HRI	When HRI > 85.0
	When HRI ≥ 35.0 and ≤ 58.0 I = 1.614 - 0.02783 x HRI		When HRI > 85.0 I = -\$0.64	

1. The pavement smoothness category will be shown on the plans.

- D. When the Contract specifies HRI Percent Improvement (%I), incentive/disincentive payments for pavement smoothness will be made on a square yard basis in accordance with the following:

The Engineer will produce a report of the original surface that will include the lane profiled and the HRI in 0.05 mile increments.

Incentive and disincentive payments will be based on the %I of the HRI for each 0.05 mile section or fraction thereof on the final paved surface compared to the HRI for each 0.05 mile section or fraction thereof on the original surface. Sections less than 0.01 miles in length will not be subject to disincentive payments.

The %I will be calculated as follows:

$$\%I = \frac{\text{HRI OF ORIGINAL SURFACE} - \text{HRI OF FINAL SURFACE}}{\text{HRI OF ORIGINAL SURFACE}} \times 100$$

Incentive/disincentive payments for Pavement Smoothness will be made in accordance with Table 105-7 or 105-8.

When the Contract specifies Rural Construction Percent Improvement, the Contractor may request in writing to the Engineer that the pavement smoothness category is changed to HRI Category I. The request shall be made prior to any work that will affect the initial smoothness of the lanes. If approved by the Engineer the requirements for HRI Category I shall apply.

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Table 105-7
HMA PAVEMENT SMOOTHNESS
RURAL CONSTRUCTION
PERCENT IMPROVEMENT (%I)
HALF-CAR ROUGHNESS INDEX

Incentive Payment (\$/sqyd)	No Incentive or Disincentive	Disincentive Payment (\$/sqyd) ¹	Corrective Work Required ¹
When %I > 60.0 I = \$0.32	When %I > 40.0 and < 45.0 I = \$0.00	When %I ≥ 25.0 and ≤ 40.0 I = (32 x %I - 1280)/1500	When %I < 20.0
When %I ≥ 45.0 and ≤ 60.0 I = (32 x %I - 1440)/1500		When %I < 25.0 I = -\$0.32	
1 Disincentives will not be assessed and corrective work will not be required for a 0.05 mile section if the HRI is equal to or less than 80.0 in/mi			

Table 105-8
HMA PAVEMENT SMOOTHNESS
URBAN CONSTRUCTION
PERCENT IMPROVEMENT (%I)
HALF CAR ROUGHNESS INDEX

Incentive Payment (\$/sqyd)	No Incentive or Disincentive	Disincentive Payment (\$/sqyd) ¹	Corrective Work Required ¹
When %I > 50.0 I = \$0.32	When %I > -5.0 and < 5.0 I = \$0.00	When %I ≥ -20.0 and ≤ -5.0 I = (32 x %I + 160)/1500	When %I < -25.0
When %I ≥ 5.0 and ≤ 50.0 I = (32 x %I - 160)/4500		When %I < -20.0 I = -\$0.32	
1 Disincentives will not be assessed and corrective work will not be required for a 0.05 mile section if the HRI is equal to or less than 80.0 in/mi			

(c) *Corrective Work.*

Corrective work shall be proposed in writing by the Contractor. Corrective work shall not be performed until approved in writing by the Engineer. The Contractor shall not perform any corrective work on the final layer until after the Engineer returns the results of the Smoothness Acceptance (SA) testing and after the Department's smoothness verification testing, if performed. Corrective work on lower layers shall be at the Contractor's discretion. The Department will analyze the SA testing for acceptance and indicate areas requiring corrective work in accordance with subsection 105.07(b). Incentive/disincentive payments will be based on the Contractor's SA testing. The Contractor shall verify and perform corrective work in the areas indicated by the SA testing. The Contractor shall profile the roadway to verify that the required corrective work has been completed.

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1. Half-Car Roughness Index Corrective Work:

- A. The criteria for determining if a 0.1 mile section or fraction thereof requires corrective work is specified in Table 105-6. In addition to determining if a 0.1 mile section or fraction thereof requires corrective work, the profiles shall be analyzed for areas of Localized Roughness.
- B. Localized Roughness. The profiles shall be analyzed to determine where areas of localized roughness occur. The profile shall be summarized using the continuous HRI reporting system using an averaging length of 25 feet. The latest release of the FHWA's ProVal software shall be used to generate the continuous HRI report. ProVal can be downloaded at <http://www.roadprofile.com>.

Areas shall be considered deficient, and require corrective work where the continuous HRI report exceed 150.0 inches per mile. Areas where the continuous HRI report exceeds the values in Table 105-9 but are less than 150.0 inches per mile shall be tested in accordance with subsection 105.07 (a) 2.

Table 105-9
CONTINUOUS HRI USING 25 FOOT AVERAGING FOR LOCALIZED
ROUGHNESS CORRECTIVE WORK ON HMA PAVEMENTS

HRI SMOOTHNESS CATEGORY	HRI In/mile
I	135.0
II	125.0

2. Half Car Roughness Index Percent Improvement Corrective Work. The criteria for determining if corrective work is required for a 0.05 mile section or fraction thereof is specified in Table 105-7 or 105-8. The Engineer may also test any section of the roadway in accordance with subsection 105.07(a) 2.

When the corrective work is complete, the Contractor shall re-profile the corrective work area and determine a HRI Percent Improvement for each 0.05 mile section or fraction thereof. Additional corrective work in accordance with this specification will be required if the HRI Percent Improvement for a 0.05 mile section or fraction thereof doesn't meet the specified range shown in Table 105-7 or 105-8.

If corrective work is required, the Contractor shall submit a written corrective work proposal to the Engineer, which shall include the methods and procedures that will be used. The Contractor shall not commence corrective work until the methods and procedures have been approved in writing by the Engineer.

The Engineer's approval shall not relieve the Contractor of the responsibility of producing work in conformity with the Contract.

3. Corrective Methods. Corrective work shall consist of diamond grinding an approved overlay, or removal and replacement.

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Corrective work shall conform to one of the following conditions:

- (1) Removal and Replacement. The pavement requiring corrective work shall be removed, full width of the lane and the full thickness of the layer in accordance with subsection 202.09.

The removal area shall begin and end with a transverse butt joint, which shall be constructed with a transverse saw cut perpendicular to centerline. Replacement material shall be placed in sufficient quantity so the finished surface conforms to grade and smoothness requirements. Sections removed and replaced shall be at least 0.2 miles in length.

- (2) Overlay. The overlay shall cover the full width of the pavement including shoulders. The area overlaid shall begin and end with a transverse butt joint, which shall be constructed with a transverse saw cut and asphalt removal. All material shall be approved hot bituminous mixtures that meet all contract requirements. The overlay shall be placed so that the finished surface conforms to grade and smoothness requirements. The overlay area shall be compacted to the specified density. The overlay thickness shall be equivalent to that of the final pass made in accordance with the Contract. Sections overlaid shall be at least 0.2 miles in length.

- (3) Diamond Grinding. Grinding shall not reduce planned pavement thickness by more than 0.3 inches. The entire ground area of the final pavement surface shall be covered with a Tack Coat conforming to Section 407 (CSS-1h at 0.1 gallons per square yard of diluted emulsion; the emulsion shall be diluted with water at the rate of 50 percent water and 50 percent emulsion) when grinding is complete.

- (d) *Department Smoothness Verification Testing (SV)*. The Department may elect to perform smoothness verification (SV) testing using the Department's inertial profiler, with the methods described in subsection 105.07(b). The Engineer will notify the Contractor of the Department's intention to perform SV testing. All traffic control costs associated with Department SV testing will be paid for by the Department in accordance with Section 630.

The Contractor's SA test results will be compared to the Department's SV test results. The Contractor's SA test results will be considered acceptable and will be used for incentive/disincentive payment if the following criteria are met:

- (1) The difference in HRI for a 1/10 mile section is less than 6.1 inches/mile for a minimum of 90 percent of the 1/10 mile sections for each lane.
- (2) The difference in average HRI for each lane is less than 6.1 inches/mile.
- (3) The difference in the length of each lane is less than 0.2 percent

When the Contractor's SA test results are not considered acceptable, the Department's SV test results will be used for incentive/disincentive payment and the Contractor's profiler certification shall be evaluated pursuant to CP 78. The Department will have 30 days to complete this evaluation.

The Contractor will be assessed a charge of \$1,000 for SV testing when the Contractor's SA test results are not considered acceptable.

In subsection 202.09 delete the last paragraph

Delete subsection 401.20 and replace with the following:

401.20 Surface Smoothness. The roadway surface smoothness shall be tested in accordance with subsection 105.07 except when only one layer less than 1.5 inches of HMA Pavement is placed without an intermediate treatment. HMA Pavements less than 1.5 inches without an intermediate treatment shall meet the smoothness requirements of subsection 406.11.

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Delete Subsection 406.11 and replace with the following:

406.11 Smoothness. The longitudinal surface smoothness of the roadway prior to and after cold recycling shall be tested in accordance with subsection 105.07 by the Contractor.

Testing procedures. An HRI for each 0.1 mile section shall be determined on the original pavement surface prior to beginning the work.

An HRI for each 0.1 mile section shall be determined on the pavement surface after the work is complete.

Final pavement smoothness criteria will be as follows:

When a 0.1 mile section has a final HRI greater than 80.0 in/mile and the final HRI is greater than the HRI prior to performing the work, that 0.1 mile section shall be corrected by a method approved in writing by the Engineer. Corrective work shall be such that the resulting final HRI is equal to or less than the initial HRI or 80.0 in/mile, whichever is greater. All costs associated with corrective work shall be at the Contractor's expense, including but not limited to traffic control, additional hot mix asphalt, grinding and milling.

Delete subsection 601.15 (f) 2. and Table 601-2.